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PSYCHOLOGY AND SCIENTIFIC METHODS

CRITIQUE OF COGNITION AND ITS PRINCIPLES¹

THE German philosophical terminology distinguishes between "Erkenntnis" and "Kenntnis, Wissen"; this distinction, though varying with the different authors, has been of high importance in the development of idealism; yet there seems to be no accepted fixation in the English language for these two concepts. I shall in this paper use cognition for Erkenntnis, as knowledge already stands for Kenntnis, and shall place the distinction between cognition and knowledge in the concept of system. Knowledge that satisfies the group of conditions for which the concept of system stands, is cognition. This group of conditions and therewith the definition of cognition I shall not give here, but instead point out particular instances of cognition: mathematics, mechanics stand as examples and also as parts of cognition. It seems advisable, in order to give determinateness and stability to the concept of cognition, to restrict it at first and to relate it to mathematics and mechanics only, with the provision, however, of properly extending it afterwards. Whether such an extension is possible, and what the scientific methods of such an extension are, is the subject of a special investigation; but whatever the decision of such an investigation may be, it will not affect the inquiry we are concerned in, which is independently necessary. Systems in this paper, therefore, are always systems of mathematics or of mechanics.

By "logic of cognition" I understand the systematic construction of the foundations of cognition from the true origin. This logical origin is the concept of "problem." Inasmuch as the problem may be conceived as generating a system, I call it the "generating problem." The construction of the foundations may be considered as the positing of the conditions necessary and sufficient for the solution of the problem of cognition. These conditions are the axioms or principles; they are not arbitrary (mere "conventions"), as some take it, but necessary—though in a sense of the word different from the necessity of a theorem: theorems derive their necessity from axioms,

¹ Read before the American Philosophical Association in 1902; published with several additions.

they are necessary *from*; axioms derive their necessity from the generating problem, they are necessary *for*, namely, for the solution of the problem. There is no necessity beyond the problem.

Logic of cognition is purely constructive; it posits nothing as given but its problem; and whilst it thus appears as the true basis of the system of cognition, which it makes possible, it requires a new discipline preliminary to it which establishes its problem, determines its method, and prepares its material. For construction is not generation out of nothing, nor is the logical origin a psychologically new beginning. This preliminary discipline establishes the true interrelation between logic of cognition and cognition as it is represented in its literature; and in this interrelation the advance toward the ideal of cognition is accomplished.

By "critique of cognition" I understand the examination of the actual, or possible, systematic solutions of the problem of cognition *according to principles*. This critique is the required preliminary discipline and is established with reference to a possible system of logic of cognition. "Critique of cognition" posits cognition as given. The distinction between a critique of cognition and a logic of cognition consists, therefore, in this: the first examines, the second constructs.

All criticizing is measuring and therefore presupposes a standard. According to the standard taken, there are three kinds of "critique" possible: the external, the internal (or immanent), and the systematic. The external takes as standard any other system and measures the agreement or disagreement with it. The internal measures a system by itself in the agreement or disagreement of its parts. The systematic takes as standard a complete set of critical principles to determine the objective value of the system. "Critique of cognition" is, by definition, of the third kind.

It is our task to exhibit such a set of principles. We are guided by the idea with which we started, that cognition is essentially systematic; the principles by which any system may be criticized are, therefore, the principles of "critique of cognition," and we obtain them if we consider a particular instance and remove the specializing conditions.

In the introduction to his "Prinzipien der Mechanik," Heinrich Hertz has given such a set of principles and applied them to systems of principles of mechanics. But they are based on a metaphysical assumption of which "critique of cognition" can, and therefore ought to, be free.

The principles by which the value of a system may be judged seem to me to form four groups of conditions; I call them: the conditions of logical *purity*, of logical *completeness*, of logical *simplicity* and of logical *truth*.

CONDITIONS OF LOGICAL PURITY

1. *The concepts must be well determined.*—Derived concepts are determined in their definitions. Fundamental concepts can not be defined; methods must be indicated in the system for their determination and it is not sufficient to enumerate them in the beginning as “primitive concepts,” as Peano and his school have done.

2. *The definitions must be good.* A definition is the establishment of a group of conditions between certain elements. The introduction of a new name for this group of conditions and therefore the form of an equation which Peano² and others have declared as essential, does not concern the true nature of a definition.

A definition is good if it satisfies the following conditions: (a) Its elements must be well determined; (b) the conditions to which the elements are submitted, must be independent, *i. e.*, they must all be necessary (indispensable); (c) all independent conditions must be stated, *i. e.*, the conditions must be sufficient; (d) the conditions must be consistent. If we take, *e. g.*, the definition: A circle is a curved line whose points are equidistant from one point, it may satisfy condition (a), and it does satisfy condition (d) (because we can construct lines which satisfy the definition); but it does not satisfy conditions (b) and (c), because the condition “curved” is deducible from the others (therefore not independent), and the condition “equidistant” is not sufficient to determine a circle, since it includes, besides, each part of a circle and all curves on a sphere in the definition.

3. *The fundamental as well as the special conditions of the system must be consistent.*

4. *The conclusions must be correct.* This condition comprises: (a) That the conclusions satisfy the rules of the syllogism, which, using symbolical notations, have been summed up in one formula, the “argument of inconsistency,” by Mrs. Ladd-Franklin;³ (b) that the limiting conditions, under which the premises are valid, are observed; (c) that no principles are used except those which are explicitly presupposed, or proven as theorems.

These four conditions determine the logical purity of the system with respect to its generating problem; they apply, with obvious modifications, as well to the generating problem itself. In particular, the non-satisfaction of the condition of consistency (3) leads to so-called null-systems.

² See “Les Définitions Mathématiques, Bibliothèque du Congrès International de Philosophie,” Vol. III. (1900), p. 279. See also: “Formulaire,” Vol. I. (1895), p. iv.

³ See “Studies in Logic,” by members of the Johns Hopkins University, p. 40.

CONDITIONS OF LOGICAL COMPLETENESS

1. The fundamental conditions of the system itself, as well as the special conditions of each theorem, must be sufficient; *i. e.*, all special problems (called "facts" in physics) within the realm of the generating problem must be deducible from the system. The method of ascertaining the satisfaction of this condition is the method of the constructed exception (called "experiment" in physics). This method will indicate sufficiently the importance of the condition for physics; it is equally great in mathematics, and closely allied to the "spirit of exactness."

This first condition determines the completeness of the system with respect to its generating problem. A second condition requires the completeness of the generating problem itself and may be formulated thus:

2. All special problems which belong to the realm of the generating problem must be contained in this realm of the generating problem. The difficulty of the condition lies in this: How can we determine that a special problem belongs to a realm unless it is actually contained in it? It is the same difficulty as the following: How can we determine that a definition is not complete? Whilst this condition has shown its influence in the history of science, it is not so evident for the reason that the generating problems are but rarely explicitly stated. Yet the definition of the science will always contain it. Take, *e. g.*, "geometry is that part of mathematics which is concerned with spatial magnitudes." This generating problem violates our condition because it does not contain the problems of modern projective geometry. Or, if we should formulate the generating problem of geometry, with modern geometers, purely projectively, and accept Mr. Bertrand Russell's proof that the projective definition of distance only superficially contains the Euclidean, then we should maintain that the special problems of Euclid's geometry are not all contained in the realm of our generating problem. In both cases the system might be complete so far as our first condition of completeness is concerned. It is evident that the method of testing the satisfaction of this second condition is the same as that of the first.

Another method of testing the satisfaction of these conditions of completeness is to show that the system embraces another system which has already been tested. One system embraces another if the content of the second can be deduced from the first; *e. g.*, to show that a set of axioms is complete for metrical geometry, it is sufficient to show that from the set an established set can be deduced.⁴ The

⁴ *E. g.*, Professor J. Royce's paper: "The Relation of the Principles of Logic to the Foundations of Geometry," in *Transactions of the American Mathematical Society*, Vol. 6 (1905), No. 3, pp. 410 ff.

method is, however, applicable only under certain restrictions which can not be discussed here. It has sometimes, though mistakenly, been used to prove the *possibility* of a system.⁵

CONDITIONS OF LOGICAL SIMPLICITY

1. *The fundamental conditions must be simple.* The work of modern mathematicians has shown that an interchange between principles and propositions is possible, so that different solutions of the same generating problem can be obtained by a proper change in the choice of theorems as principles. However, there seems to exist between the principles (and the concepts to which these principles correspond) a definite relation such that we call the one simpler, the other more complex. It must be possible to determine this relation in the various concrete cases, though it is hard to state it in general. If it is found, our condition gives preference to the system which has the simpler principles and concepts; so that it is not of equal value for the system, though it may be logically indifferent, which is made the foundation and which the derived. As an illustration note Heinrich Hertz's objection to Hamilton's principle as a fundamental principle of mechanics.⁶

2. *The fundamental conditions must be few.* Either the number of principles may be different in the different selections of principles referred to in the preceding condition, (1), or auxiliary principles may be required; preference is given by our condition to the smaller number, unless it is in opposition to the preceding condition. As an illustration see Professor E. V. Huntington's definition of a group,⁷ as compared with the one given by H. Weber in his "*Lehrbuch der Algebra*,"⁸ or v. Helmholtz's objections to W. Weber's theory of electrodynamics.⁹

3. *The fundamental conditions must be mutually independent ("necessary").* The method of ascertaining the satisfaction of this condition consists in the construction of a system which satisfies all

* See H. Hertz, "Prinzipien der Mechanik," p. xxiv: "Dass aber die gegebene Zusammenstellung in jeder Hinsicht eine *mögliche* ist, beweise ich dadurch, dass ich ihre Folgen entwickle und zeige, dass bei voller Entfaltung sie den Inhalt der gewöhnlichen Mechanik aufzunehmen vermag. . . ." It is, however, clear, firstly, that therewith the possibility of one system is merely set in relation to that of another; secondly, that for this a special principle would be required, which may be formulated thus: if from a set of conditions we can deduce possible results, the set is itself possible; and thirdly, that the real question at issue is not the possibility but the relative completeness of the two systems.

* "Prinzipien der Mechanik," p. 27.

⁷ *Bulletin of the Am. Math. Society* (1902), second series, Vol. VIII., No. 7, pp. 296-300.

⁸ Vol. II. (1899), pp. 3-4.

⁹ H. Hertz, "Mechanik," Vorwort, pp. x-xi.

the conditions with the exception of the one whose independence is in question. The application of this condition to Euclid's axioms of geometry has led to new systems of geometry and to a revision of the foundations of Euclidean geometry.

The first three conditions of this group determine the simplicity of the system with respect to the generating problem. A fourth condition requires the simplicity of the generating problem itself, and may be formulated thus:

4. *The realm of the generating problem must contain only those special problems which belong to it.* The difficulty of the condition lies in this: How can we determine that a special problem does not belong to a realm unless it is actually not contained in it? It is the same difficulty as the following: How can we determine that a definition is too broad?

This group of conditions has been of the utmost importance in the development of science. If we consider that any system can be made complete by the addition of auxiliary hypotheses (conditions), it will be evident that this group is the necessary correlate to the preceding group (of completeness), and not merely the satisfaction of an esthetic demand, as some hold.

CONDITIONS OF LOGICAL TRUTH

1. The system must be a solution of its generating problem such that the preceding groups of conditions are satisfied.

2. The generating problem of the system must be a special case of the general problem of cognition, *i. e.*, each special system must be a special problem within the realm of the generating problem of cognition.

It is evident from these conditions that truth is the highest of all the critical conditions, and that the problem of "critique of cognition" could be formulated as the determination of the truth-value of a system. It follows further (from 2) that it is not the task of the single disciplines to determine the truth of their systems. This conclusion is so paradoxical and is liable to meet so strong an opposition, especially from the physicists, that it is necessary to consider it from another point of view.

Whatever these conditions may be, the proper method of determining truth, at least in physics, seems to be the *experiment*. It can easily be shown, however, that the experiment, whilst it is indeed the most powerful means of convincing us of the possible truth of a system, is nothing but the method of the conditions of completeness. In so far, and in so far only, as their satisfaction is required by the condition that "the system must be a solution of its generating problem" (1) can the experiment be considered as a negative criterion

of truth. Foucault's experiments to determine the velocity of light in water left no doubt about the superiority of the undulation theory. They did not, however, prove the truth of Huyghens's theory, but only the incompleteness of Newton's; or, as Foucault himself expresses it, "The last conclusion which I draw from my experiment, is, therefore, the proof that the emission hypothesis is not in harmony with the phenomena of light." Again Fresnel's experiments in the interference of rays of light, as they were a direct consequence of the undulation theory, strongly increased our conviction of the truth of this hypothesis; but what they proved is the completeness of Huyghens's system with respect to a certain group of special problems.

This granted, the conclusion might be drawn that the conditions of completeness are the conditions of truth.¹⁰ It is obvious, however, that this would mean to ignore the other conditions. But we are thus led to the question: Is the set of conditions that we have given complete, is it simple, pure, etc.? In other words: this set of conditions¹¹ can itself be considered as a system and therefore be examined by its own principles. I call it the "self critique" of the critical principles.

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CLEARNESS, INTENSITY, AND ATTENTION

MUCH has been made in late years of the distinction between intensity and vividness, or clearness, which attracts our notice in the study of attention. But it appears clear to the writer that the distinction is one merely between intensities of different types. Most of the studies of our psycho-physicists in this direction are given to sensational intensities, and in this field they observe intensity as contrasted with clearness, vividness, distinctness, but fail to take sufficient note of the fact that this contrast appears in other realms than the sensational.

Titchener tells us¹ that "the problem of attention centers in the fact of sensible clearness": and² that "clearness is an independent attribute of sensation" which "may vary independently of intensity"; although "change of clearness always involves a change of intensity as well." One can not but hesitate to question so positive a statement of so thoroughly equipped and thoughtful a psychol-

¹⁰ This is essentially, if I understand him correctly, Professor James's theory in his book on "Pragmatism."

¹¹ As was first pointed out to me by Mrs. Schmidt.

¹ "The Psychology of Feeling and Attention," p. 182.

² *Op. cit.*, p. 219.